Use of organic acids as feed additives - sustainable aquaculture production the non-antibiotic way

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The current situation in world food supply calls for supreme efforts to ensure the increasing requirements of the growing world population for staple diets and high-quality food, as well as to bridge the widening gap between food demand and supply, especially in developing areas. Setbacks in any food production sector will place greater pressure on other sectors for supplying the increasing urban and rural populations, particularly in less developed countries. Around one billion people are dependent on fish as their main protein resource, and this number is likely to increase further (Becker & Focken, 1998), since the world population is increasing at an estimated annual rate of 2.0%.

Aquaculture now provides more than 22% of consumable aquatic products (Guillaume et al., 2001). Between 1987 and 1996, aquaculture production of food fish increased by 148% (Tomasso & New, 1999), while livestock meat and fisheries have grown yearly only by 3% and 1.6% respectively. Aquaculture is at present the only growing sector within the fishing industry and is also reputed to be the fastest growing food production sector in the world.

Since the early 1980s, yearly growth rates of around 10% have been reported for the aquaculture sector. Because of this situation, global production of farmed fish and shellfish has more than doubled in volume and value in the past 15 years (Naylor et al., 2000). If products from aquaculture that are not directly used for human consumption are included, then the world's aquaculture production more than tripled by weight and value between 1984 and 1996 (Dagoon, 2000). The contribution of aquaculture to total fish production directly consumed by humans is currently more than 25%.

Sustainable aquaculture and use of antiobiotics

The promotion of environmentally sound practices in all fields of fish and shrimp production is a relevant point for the aquaculture industry if sustainability is to be achieved (Williams et al., 2000). The growing awareness from consumers and producers has resulted in calls for responsible and sustainable aquaculture. Public opinion and regulation authorities in most export countries focus now on the misuse of antibiotics in aquaculture and public attention has shifted towards production methods (Verbeeke, 2001; Feedinfo, 2005). Furthermore, the EU has banned all antibiotic growth promoters from livestock production with effect of January 2006, since the use of low levels of these antibiotics in animal feeds possesses the possibility to transfer bacterial immunity to species pathogenic in animals and humans (Liem, 2004).

In the field of aquaculture it is well established that the inclusion of antibiotics into the diets of fish (Ahmad & Matty, 1989) can promote growth and feed conversion. Due to the above mentioned facts however, alternatives needed to be found.

Acid preservation

Acid preservation of fish and fish viscera to produce fish silage has been a common practice and its final product has been widely used in fish feeds with reported beneficial effects (Gilbert & Raa, 1977; Åsgård & Austreng, 1981). These beneficial effects of acid preserved products caught the attention of the scientific community to investigate the dietary effects of using these short-chain acids on fish directly. Several studies have been conducted with different species, including carnivorous species such as rainbow trout Oncorhynchus mykiss, Atlantic salmon Salmo salar and artic charr Salvelinus alpinus, herbivorous filter feeders such as tilapia, and also with shrimp.

Table 1: Influence of dietary treatment with an organic acid blend on Rainbow trout Oncorhynchus mykiss performance compared to an antibiotic growth promoter (AGP); data from de Wet (2005)

Parameter	Control	AGP	5 kg / t acidifier	10 kg / t acidifier	15 kg / acidifier
Initial weight (g)	40.3	42.3	40.0	37.3	37.2
Final weight (g)	184.8[a]	235.4[b]	205.6[ab]	231.2[b]	231.4[b]
FCR	1.22	1.10	1.09	1.08	1.04
SGR (%)	1.23[a]	1.37[b]	1.23[a]	1.29[ab]	1.37[b]
Survival (%)	82.7	88.8	85.0	85.8	89.6

[ab]within rows, means without common superscripts are significantly different ($p<0.05$)

FCR – Food Conversion Ratio (Feed fed/Weight gain), SGR – Specific Growth Rate (% per day)

Rainbow trout feeding trials

In a recent trial the inclusion of organic acid salts in fish diets was tested in rainbow trout (de Wet, 2005). This study aimed to evaluate an organic acid blend (5-15 kg/tonne feed), mainly consisting of formate and sorbate, for its use in trout nutrition to improve performance parameters, and to compared it with an antibiotic growth promoters (40 mg/kg Flavomycin). Rainbow trout fingerlings (37-42 g initial body weight) were kept in flow-through ponds and fed there three times daily to apparent satiety. The experiment lasted for three months.

Fish feeding on 10 and 15 kg acidifier per tonne feed diets had significantly higher final weights compared to the negative control group, while there was no difference to the group treated with AGP. Feed conversion ratio tended to be lower with increasing dosages of the acid blend, even if compared to the AGP group.

The results of this study clearly shows that the application of the acidifier at 15 kg/tonne feed significantly improved weight gain and feed conversion ratio in trout compared to a negative control by 20.1% and 14.8% respectively. This data confirms that the dietary inclusion of organic acids is suitable for use in Rainbow trout grower feeds at and above levels of 10 kg acidifier per tonne of finished feed and that this level can be an effective alternative compared to the use of AGP's in trout aquaculture.

Table 2: Effects of potassium-diformate on growth performance in tilapia challenged with V. anguillarum; data from Ramli et al. (2005)

Parameter	Control	2 kg / t acidifier	3 kg / t acidifier	5 kg / t acidifier
Initial weight (g)	16.7	16.7	16.7	16.7
Final weight (g)	218[a]	258[c]	246[b]	252[bc]
FCR	1.34[a]	1.23[b]	1.25[b]	1.22[b]
Mortality (%), day 10-85	33.0[a]	20.8[b]	18.4[b]	11.0[c]

[abc]within rows, means without common superscripts are significantly different ($p<0.05$)

Beneficial effects of organic salts in fish feeds

Previous studies have also shown the beneficial effect of inclusion of organic salts in fish feeds for other species. The effect of supplementation of commercial diets with sodium salts of lactic and propionic acid (10 kg/tonne of feed) was tested in Arctic charr under brackish water conditions at 8°C (Ringø, 1991). Fish fed the diet with added Na-lactate increased their body weight from 310 g to 630 g in 84 days during the experiment, while the difference to the negative control group (final weight of fish: 520 g) was significantly ($p<0.05$) different. The inclusion of Na-propionate however had a growth depressing effect compared to the control. The gut content from Arctic charr fed the sodium-lactate supplemented diet contained significantly ($p<0.05$) lower amounts of water, energy, lipid, protein and free amino acids. It has been observed that charr feeding on high doses of commercial feeds, as it often appears under aquaculture conditions, have a tendency for diarrhoea. When charr was feeding on Na-lactate no nutritive diarrhoea appeared, probably because of much lower amounts of remaining nutrients and water in the gut. Furthermore, it was proposed that the growth promoting effect of dietary lactate in Arctic charr is caused by the relatively slow gastric emptying rate (Gislason et al., 1996). An increased holding time in the stomach augments the antibacterial potential of the lactic acid salt and can have therefore a larger inhibition effect against possible pathogenic bacteria (Sissons, 1989). The improved growth of the Artic charr did not affect the chemical composition of the fish (Ringø et al., 1994).

Feeding Na-lactate to Atlantic salmon juveniles (15 kg/tonne feed) however did not show such a pronounced effect (Ringø et al., 1994; Gislason et al., 1996) compared to charr. Ringø et al. (1994) found slightly increased survival rates in salmon feeding on lactate (84.8% compared to 80.1%), while Gislason et al. (1996) reported a higher specific growth rate (SGR). However, none of these differences were statistically significant. These findings may suggest that the influence of lactate is a result of some differences in digestive physiology between the two fish species, for instance a longer retention time of lactate in the stomach in charr. But lower bacterial challenge, due to the use of the organic acid salt, may have lead to the tendency of higher survival rates.

The use of organic acids however has not only been tested in Salmoniformes, but have also been tested in tropical warm-water species, such as tilapia. For example, Ramli et al. (2005) tested the use of potassium-diformate as a non-antibiotic growth promoter in tilapia grow-out in Indonesia. In this study fish were fed over a period of 85 days 6 times a day with different dietary concentrations of potassium-diformate (0, 2, 3 and 5 kg/tonne feed). Furthermore, fish were challenged orally starting on day 10 of the culture period with Vibrio anguillarum at 105 CFU per day over a period of 20 days.

Over the whole feeding period from day 1 to day 85 potassium-diformate significantly increased weight gain and feed efficiency in tilapia. Survival rates of fish after the challenge with V. anguillarum on day 10 were also significantly higher compared to the negative control and the effect was furthermore dose dependent. The 2 kg/tonne dietary inclusion of the potassium salt of formic acid led to an improvement in weight gain and feed conversion ratio in tilapia by 18.6% and 8.2% respectively, and indicate furthermore that the acidifier was able to counteract bacterial infection in tilapia.

Finally, a recent report (Lückstädt, unpublished data) suggests that a dosage of 2.5 kg/tonne Ca formate can enhance the survival rates in brackishwater shrimp grow-out in Taiwan. However, these shrimp feeding trials need to be repeated over several growing seasons.

Concluding remarks

On the basis of the above mentioned studies it can be seen that the use of organic acid salts or acid blends is an interesting option to promote the growth performance and health of a wide variety of aquaculture species worldwide. Moreover, it is suggested that the impact of bacterial infections can be reduced which in turn may lead to higher

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survival rates. The use of dietary acidifiers in aquaculture can be therefore an efficient tool to achieve a sustainable and cost-effective fish and shrimp production.

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